U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

AMERICAN STANDARD BUILDING CODE REQUIREMENTS FOR MASONRY

MISCELLANEOUS PUBLICATION M174

U. S. DEPARTMENT OF COMMERCE
JESSE H. JONES, Secretary
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LYMAN J. BRIGGS, Director

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AMERICAN STANDARD BUILDING CODE REQUIREMENTS FOR MASONRY

By

Sectional Committee on Building Code Requirements and Good Practice Recommendations for Masonry—A41

Under the Sponsorship of the National Bureau of Standards

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FOREWORD

This standard, developed under ASA project A41, Building Code Requirements and Good Practice Recommendations for Masonry, presents recommended building code requirements for nonreinforced masonry.

The standard is one of a related series presenting recommended basic building code requirements that are being developed by technical committees under the procedure of the American Standards Association. The general building code program is under the supervision of the Building Code Correlating Committee of the Association.

The objectives of the program and information concerning the several technical committees and the Building Code Correlating Committee are given in an announcement, *Building Code Standardization,* which may be obtained from the American Standards Association

LYMAN J. BRIGGS, *Director*

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American Standard Building Code Requirements For Masonry

By

Sectional Committee on Building Code Requirements and Good Practice Recommendations for Masonry—A41

Under the Sponsorship of the National Bureau of Standards

ABSTRACT

Building Code Requirements for Masonry (ASA A41.1–1944) is a complete code of minimum requirements for masonry construction including definitions, requirements for materials, allowable stresses, and general requirements for all types of masonry except reinforced masonry. This document, prepared by American Standards Association Sectional Committee A41 under the sponsorship of the National Bureau of Standards, is one of a series of building code standards prepared by various committees under the jurisdiction of the Building Code Correlating Committee of the American Standards Association. The basis of the requirements of this code is discussed in an appendix.

SECTION 1. GENERAL

1–1. Application of requirements.

(a) Masonry, as defined in this standard, when used in any building or structure shall conform to these requirements.

(b) A material other than one of those specifically named in the definition of masonry, which is incombustible and otherwise sufficiently embodies the characteristics of one of the materials named, and which satisfies the requirements for that material, may be classed by the building official with that material which it most closely resembles.

1–2. Definitions.

ACI means the American Concrete Institute.

ASA means the American Standards Association.

ASTM means the American Society for Testing Materials.

FS means Federal Specification.

Approved, as applied to a material, device, or mode of construction, means approved by the building official under the provisions of the building code, or by other authority designated by law to give approval in the matter in question.

Architectural terra cotta is plain or ornamented (modeled or molded) hard-burned building units, larger in size than brick, consisting of mixtures of plastic clays, fusible minerals, and grog, and having a glazed or unglazed ceramic finish.

Ashlar facing is a facing composed of solid rectangular units of burned clay or shale, or natural or cast stone, larger in size than brick, having sawed, dressed, or squared beds, and joints laid in mortar.

Ashlar masonry is masonry composed of rectangular units of burned clay or shale, or natural or cast stone, larger in size than brick and properly bonded, having sawed, dressed, or squared beds, and joints laid in mortar.

Brick is a material of construction in small, regular units, formed from inorganic substances and hardened in a shape approximating a rectangular prism approximately 8 by 3¾ by 2¼ inches in size, the net cross-sectional area of which in any plane parallel to the bearing surface is not less than 75 percent of its gross cross-sectional area measured in the same plane.

Building means a combination of materials to form a construction that is safe and stable, and adapted to continuous occupancy for residence, business, industrial, assembly, or storage purposes. The term *building* shall be construed as if followed by the words "or part thereof."

Building official means the officer or other person charged with the administration and enforcement of the building code, or his duly authorized representative.

Concrete masonry unit is a building unit made from cement and suitable aggregates, such as sand, gravel, crushed stone, cinders, burned clay or shale, or blast-furnace slag.

Height as applied to a wall means the vertical distance to the top, including parapet, measured from the foundation wall, or from a girder or other immediate support of the wall.

Hollow masonry unit is a masonry unit whose net cross-sectional area in any plane parallel to the bearing surface is less than 75 percent of its gross cross-sectional area measured in the same plane.

Masonry means architectural terra cotta, brick, and other solid masonry units of clay or shale, concrete masonry units, glazed building units, gypsum tile or block, plain concrete, stone, structural clay tile, structural glass block, or other similar building units or materials, or a combination of same, bonded together with mortar.

Mortar is a plastic mixture of cementitious material, fine aggregate, and water.

Nominal dimension is a dimension that may vary from actual masonry dimension by the thickness of a mortar joint but not to exceed one-half inch.

Partition.

Bearing partition is an interior bearing wall one story or less in height.

Nonbearing partition is an interior nonbearing wall one story or less in height.

Pier means an isolated column of masonry; a bearing wall not bonded at the sides into associated masonry shall be considered a pier when its horizontal dimension measured at right angles to the thickness does not exceed four times its thickness.

Required means required by some provision of these requirements.

Rubble.

Coursed rubble is masonry composed of roughly shaped stones fitting approximately on level beds and well bonded.

Random rubble is masonry composed of roughly shaped stones laid without regularity of coursing, but well bonded and fitted together to form well-defined joints.

Rough or ordinary rubble is masonry composed of unsquared or field stones laid without regularity of coursing but well bonded.

Solid masonry is masonry consisting of solid masonry units laid contiguously with the joints between the units filled with mortar, or consisting of plain concrete.

Solid masonry unit is a masonry unit whose net cross-sectional area in every plane parallel to the bearing surface is 75 percent or more of its gross cross-sectional area measured in the same plane. Net cross-sectional area shall be taken as the gross cross-sectional area minus the area of the cores or cellular space. Gross cross-sectional area shall be determined to the outside of the scoring, but the cross-sectional area of the grooves shall not be considered as part of the area of the coring and shall not be deducted from the gross cross-sectional area to obtain the net cross-sectional area.

Story is that portion of a building included between the upper surface of any floor and the upper surface of the floor next above, except that the top story shall be that portion of a building included between the upper surface of the highest finished floor and the ceiling or roof above.

Structural clay tile is a hollow masonry unit composed of burned clay, shale, fire clay, or mixtures thereof and having parallel cells.

Walls.

Bearing wall is a wall which supports any vertical load in addition to its own weight.

Cavity wall is a wall built of masonry units or of plain concrete, or a combination of these materials, so arranged as to provide an air space within the wall, and in which the facing and backing of the wall are tied together with metal ties.

Faced wall is a wall in which the masonry facing and backing are so bonded as to exert common action under load.

Foundation wall is a wall below the floor nearest grade serving as a support for a wall, pier, column, or other structural part of a building.

Hollow wall of masonry is a wall built of masonry units so arranged as to provide an air space within the wall, and in which the facing and backing of the wall are bonded together with masonry units.

Nonbearing wall is a wall which supports no vertical load other than its own weight.

Parapet wall is that part of any wall entirely above the roof line.

Party wall is a wall used or adapted for joint service between two buildings.

Veneered wall is a wall having a masonry facing which is attached to the backing but not so bonded as to exert common action under load

1–3. Tests.—The building official may require reasonable tests of masonry materials from time to time to determine their quality and whether they conform to these requirements. Such tests shall be made in accordance with the standards prescribed for the material in question. In the absence of such standards, the building official shall specify the method and manner of making the tests.

1–4. Second-Hand Materials.—Second-hand materials shall not be used in masonry, unless such materials conform to these requirements and have been thoroughly cleaned.

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1–5. Materials and Methods of Construction Not Covered in These Requirements.

(a) The use of masonry materials or methods of construction not covered by these requirements may be permitted, provided that the materials conform to specifications insuring reasonable uniformity of the product; and that the stability and durability of the construction, and its resistance under fire exposure shall have been demonstrated to the satisfaction of the building official.

(b) Where tests are required by the building official the test assembly shall be truly representative of the construction for which approval is desired as to materials, workmanship, and details, and shall be built under conditions representative of those in building construction.

(c) Test panels to determine the strength of wall construction shall be from 4 to 6 feet in width and from 8 to 9 feet in height. Tests shall be made 28 days after fabrication of the test panel.

(d) In compressive tests the panel shall be tested as a column having a flat end at the bottom. The resultant of the load shall be applied uniformly along a line at the top parallel to the inside face, and one-third the thickness of the panel from the inside face exclusive of the wall finish. In transverse tests two equal loads shall be applied, each at one-quarter of the span from the supports.

(e) Allowable stresses in compression shall be fixed at not more than one-sixth of the average compressive strength of the test assemblies, as determined by responsible authorities.

SECTION 2. MATERIALS

2–1. Solid Masonry Units (Clay or Shale).

(*a*) Brick subject to the action of weather or soil, but not subject to frost action when permeated with water, shall conform to the requirements for grade MW brick of the Tentative Specifications for Building Brick (Made from Clay or Shale), ASTM C 62–41 T. When not subject to the action of weather or soil, brick shall conform to the requirements for grade NW brick.

NOTE.—Grade SW of the above specification should be required where brick may be subject to temperature below freezing while permeated with water.

In localities where brick conforming in physical properties to the requirements of this specification is not readily obtainable, the use of other brick should be permitted if suitable evidence of resistance to weathering is presented to the building official.

(b) Other solid masonry units of clay or shale shall meet the requirements for physical properties of brick as specified in Section 2–1 (a).

2–2. Sand-Lime Brick.—Sand-lime brick subject to the action of weather or soil, but not subject to frost action when permeated with water, shall conform to the requirements for grade MW brick of the American Standard Specifications for Sand-Lime Building Brick, ASA [1] A78.1–1942 (ASTM C 73–39). When not subject to the action of

[1] Where reference is made to standards by abbreviation of the title of the sponsor organization, the abbreviation shall have the following meaning: ASA means American Standards Association, ASTM means American Society for Testing Materials, ACI means American Concrete Institute, and FS means Federal Specification.

weather or soil, sand-lime brick shall conform to the requirements for grade NW brick.

NOTE.—Grade SW of the above specification should be required where brick may be subject to temperature below freezing while permeated with water.

2–3. Concrete brick.—Concrete brick subject to the action of weather or soil shall conform to the requirements for grade A brick of the American Standard Specifications for Concrete Building Brick, ASA A75.1–1942 (ASTM C 55–37). When not subject to the action of weather or soil, concrete brick shall conform to the requirements for grade B brick.

2–4. Structural Clay Tile.

(*a*) Structural clay tile subject to the action of weather or soil shall conform to the requirements for grade LBX tile of the American Standard Specifications for Structural Clay Load-Bearing Wall Tile, ASA A74.1–1942 (ASTM C 34–41).

(*b*) Structural clay tile used in load-bearing masonry but not subject to the action of weather or soil shall conform to the requirements for grade LB tile of the above specification.

(*c*) Structural clay tile used in interior non-load-bearing masonry shall conform to the requirements of the American Standard Specifications for Structural Clay Non-Load-Bearing Tile, ASA A76.1–1942 (ASTM C 56–41).

2–5. Concrete Masonry Units.

(*a*) Hollow concrete masonry units used in load-bearing masonry or subject to the action of weather or soil shall conform to the requirements of the American Standard Specifications for Hollow Load-Bearing Concrete Masonry Units, ASA A79.1–1942 (ASTM C 90–39).

(*b*) Hollow concrete masonry units used in non-load-bearing masonry not subject to the action of weather or soil shall conform to the requirements of the American Standard Specifications for Hollow Non-Load-Bearing Concrete Masonry Units, ASA A80.1–1942 (ASTM C 129–39).

(*c*) Solid concrete masonry units shall conform to the requirements of the American Standard Specifications for Solid Load-Bearing Concrete Masonry Units, ASA A81.1–1942 (ASTM C 145–40).

2–6. Plain Concrete.

(*a*) Cast-in-place concrete construction, reinforced only for shrinkage or temperature changes shall be classed as plain concrete. Plain concrete other than concrete fill shall have a minimum compressive strength at 28 days of 2,000 psi.

(*b*) Portland cement shall conform to the requirements of the Standard Specifications for Portland Cement, ASTM C 150–42.

(*c*) Natural cement shall conform to the requirements of the Standard Specifications for Natural Cement, ASTM C 10–37.

(*d*) Concrete aggregates shall conform to the requirements of the Standard Specifications for Concrete Aggregates, ASTM C 33–42. The maximum size of the aggregates shall not exceed one-fifth of the narrowest dimension between forms of the member for which the concrete is to be used, nor 2½ inches.

(*e*) Water used in mixing concrete shall be clean, and free from deleterious amounts of acids, alkalis, or organic materials.

NOTE.—Water suitable for drinking purposes is satisfactory.

2–7. Cast Stone.—Cast stone shall conform to the requirements of the Specification for Cast Stone, ACI 704–44.

2–8. Natural Stone.—Stone for masonry shall be sound and free from loose or friable inclusions. It shall have sufficient strength, durability, and resistance to impact for the proposed use

2–9. Architectural Terra Cotta.—Architectural terra cotta shall have a strong homogeneous body and give a sharp metallic, bell-like ring when struck. All units shall have the necessary anchor holes and shall be so formed as to engage properly with the supporting structure.

2–10. Glazed Building Units.—Glazed building units shall conform to the requirements of the Tentative Specifications for Glazed Building Units ASTM C 126–39 T except that the requirements for finish shall not apply to salt-glazed building units.

2–11. Gypsum Tile and Block.

(a) Gypsum partition tile or block shall conform to the requirements of the Standard Specifications for Gypsum Partition Tile or Block, ASTM C 52–41.

(b) Gypsum partition tile or block shll not be used in bearing walls or in exterior walls, or where subject to continous dampness.

2–12. Structural Glass Block.—Glass blocks may be solid or hollow. All mortar bearing surfaces of the blocks shall be precoated with a material to improve adhesion between mortar and glass.

2–13. Mortar Materials.

(a) Cementitious materials used in mortars shall conform to the requirements of the following applicable standard specifications:

Quicklime for Structural Purposes, ASTM C 5–26.
Hydrated Lime for Structural Purposes, ASTM C 6–31.
Hydraulic Hydrated Lime for Structural Purposes, ASTM C 141–42.
Natural Cement, ASTM C 10–37.
Masonry Cement, Federal Specification SS–C–181b.
Portland Cement, ASTM C 150–42.

(b) Aggregate for mortar shall conform to the requirements of the Tentative Specifications for Aggregate for Masonry Mortar, ASTM C 144–42 T.

Note.—Materials which have been found in practice to cause harmful volume changes should not be incorporated in masonry.

(c) Water used in mixing mortar shall be clean, and free from deleterious amounts of acids, alkalis, or organic materials.

Note.—Water suitable for drinking purposes is satisfactory.

2–14. Mortar Requirements.

(*a*) Mortar as delivered to the mason shall have a flow after suction for 1 minute of not less than 65 percent of that immediately before suction. The flow shall be determined by the method of the Water Retention Test of the Federal Specification for Masonry Cement, SS–C–181b.

(*b*) The volume of aggregate in mortar shall be at least two times, but not more than three times the volume of cementitious material.

2–15. Classification of Mortar.

(*a*) Mortar used in masonry construction shall be classified as follows:

Type	Minimum compressive strength of 2-inch cubes at 28 days
	psi
A	2,500
B	600
C	200
D	75

(*b*) Unless the strength classification of the mortar has been otherwise established by test as prescribed in Section 2–15 (c), mortars of the following proportions, with the aggregate measured in a damp and loose condition, may be assumed to meet the strength classification given in Section 2–15 (a).

Proportions by volume

Mortar type	Cement	Hydrated lime or lime putty allowable range	Aggregate measured in a damp and loose condition
A	1 (portland)	0 to ¼	Not more than 3.
B	1 (portland)	1 to 1¼	Not more than 6.
B	1 (masonry FS type II)		Not more than 3.
C	1 (portland)	2 to 2½	Not more than 9.
C	1 (masonry FS type I)		Not more than 3.
D	0 to ½ (portland)	1 to 1¼	Not more than 3 parts for each part of cementitious material.

NOTE.—The weights per cubic foot of the materials in mortar are considered to be as follows:

	Weight per cubic foot
Portland cement	94 lb.
Masonry cement	Weight printed on bag.
Hydrated lime	40 lb.
Sand, damp and loose	1 cu ft contains 80 lb of dry sand.

(*c*) Mortar of materials conforming to the requirements of Section 2–13, and of any proportions conforming to Section 2–14 (b), may qualify as mortar of any one of the four types, provided it conforms to the physical requirements of Sections 2–14 (a) and 2–15 (a).

When it is desired to establish the strength classification of a given mortar by test, the strength shall be determined with mortar prepared in a testing laboratory, of representative materials and in the proportions proposed for use. The test cubes shall be molded, cured, and tested for compressive strength as described in the Federal Specification for Masonry Cement, SS–C–181b, except that for type D mortar the entire curing shall be in laboratory air at 70° F ± 5°.

2–16. Types of Mortars Required.—Masonry shall be laid in type A, type B, or type C mortar, except as follows:

(a) Type A mortar shall be used in nominal 10-inch cavity walls, foundation walls of hollow masonry units, and masonry linings of existing masonry walls.

(b) Type A or type B mortar shall be used in footings, foundation walls of solid masonry units, isolated piers, load-bearing or exterior walls of hollow masonry units, hollow walls of masonry, and cavity walls exceeding nominal 10-inch thickness.

(c) Type D mortar may be used in solid masonry walls, other than parapet walls or rubble stone walls, not in contact with the soil and not less than 12 inches thick nor more than 35 feet in height, provided the walls are laterally supported at intervals not exceeding 12 times the wall thickness.

(d) Gypsum partition tile and block shall be laid in gypsum mortar. Nonbearing partitions and fireproofing of structural clay tile may be laid in gypsum mortar. Fire brick shall be laid in fire clay or air-setting mortar.

(e) Glass block when laid in mortar shall be laid in type B mortar.

SECTION 3. ALLOWABLE STRESSES IN MASONRY

3–1. General.

(a) Every building or structure hereafter erected and all new construction in the alteration of an existing building or structure shall be so designed and constructed that the working stresses prescribed in this section are not exceeded. In using these stresses, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account.

(b) Higher stresses than herein specified may be used, but only if it is clearly established to the satisfaction of the building official, by test or other satisfactory evidence, that material of a higher grade or a superior workmanship than is generally provided in accepted good practice is to be employed under approved inspection. The use of higher stresses, however, shall not be allowed until a statement, giving the reasons for such permission, together with the facts and circumstances on which it is based, is placed on file and made a part of the official record of the permit.

3–2. Composite Walls.—In walls or other structural members composed of different kinds or grades of units or mortar, the maximum stress shall not exceed the allowable stress for the weakest of the combinations of units and mortars of which the member is composed.

3–3. Solid Masonry Units.—The allowable compressive stresses in pounds per square inch of gross cross-sectional area in solid masonry of solid units shall not exceed the following limits:

Brick and other solid units of clay or shale; sand-lime or concrete brick

Average compressive strength of units tested in the position taken in the masonry	Mortar type			
	A	B	C	D
psi	*psi*	*psi*	*psi*	*psi*
8,000 plus	400	300	200	100
4,500 to 8,000	250	200	150	100
2,500 to 4,500	175	140	110	75
1,500 to 2,500	125	100	75	50

NOTE.—For allowable stresses in hollow walls of solid units and in cavity walls, see Section 9, Cavity Walls and Hollow Walls of Solid Units.

Solid concrete-masonry units

Grade	Mortar type		
	A	B	C
	psi	*psi*	*psi*
Grade A	175	125	80
Grade B	125	100	60

3–4. Hollow Masonry Units.—The allowable compressive stresses in pounds per square inch of gross cross-sectional area in masonry of hollow units of structural clay tile or of hollow concrete masonry units shall not exceed the following limits:

Unit	Mortar type	
	A	B
	psi	*psi*
Hollow units	85	70

3–5. Plain Concrete.—The allowable stresses shall not exceed 25 percent for compression, and 3 percent for tension in extreme fibre in flexure, of the compressive strength of the concrete. When the ratio of height to thickness of structural members of plain concrete exceeds 10, the above percentage for compression shall be reduced proportionately to 18 percent for a ratio of height to thickness of 20.

3–6. Stone and Cast Stone.—The allowable stresses in compression, in pounds per square inch of gross cross-sectional area shall not exceed the following limits:

Material	Mortar			
	A	B	C	D
	psi	*psi*	*psi*	*psi*
Granite, ashlar	800	640	500	400
Limestone, ashlar	500	400	325	250
Marble, ashlar	500	400	325	250
Sandstone, ashlar	400	320	250	160
Cast stone	400	320	250	160
Rubble stone	140	100	80	----

SECTION 4. LATERAL SUPPORT

4–1. Solid masonry walls shall be supported at right angles to the wall face at intervals not exceeding 20 times the nominal wall thickness if laid in type A, B, or C mortar, and not exceeding 12 times the nominal wall thickness if laid in type D mortar.

4–2. Walls of structural clay tile or hollow concrete masonry units, and hollow walls of masonry shall be supported at right angles to the wall face at intervals not exceeding 18 times the nominal wall thickness.

4–3. Cavity walls shall be supported at right angles to the wall face at intervals not exceeding 14 times the nominal wall thickness.

4–4. Lateral support may be obtained by cross walls, piers, or buttresses, when the limiting distance is measured horizontally, or by floors and roofs when the limiting distance is measured vertically. Sufficient bonding or anchorage shall be provided between the walls and the supports to resist the assumed wind force, acting either inward or outward. Piers or buttresses relied upon for lateral support shall have sufficient strength and stability to transfer the wind force, acting in either direction, to the ground. When walls are dependent upon floors or roofs for their lateral support, provision shall be made in the building to transfer the lateral forces to the ground.

4–5. Except for window-paneled backs, and permissible chases and recesses, walls shall not vary in thickness between their lateral supports. When a change in thickness, due to minimum thickness requirements, occurs between floor levels, the greater thickness shall be carried up to the higher floor level.

SECTION 5. SOLID MASONRY WALLS

5–1. Thickness of Solid Masonry Bearing Walls.

(a) The thickness of solid masonry bearing walls shall be sufficient at all points to keep the combined stresses due to live, dead, and other loads for which the building is designed within the limits prescribed by Section 3, Allowable Stresses in Masonry.

(b) Except as otherwise provided in this section, the minimum nominal thickness of solid masonry bearing walls shall be 12 inches for the uppermost 35 feet of their height, and shall be increased 4 inches for each successive 35 feet or fraction thereof, measured downward from the top of the wall.

(c) Where solid masonry bearing walls are stiffened at distances not greater than 12 feet apart by cross walls, or by internal or external offsets or returns at least 2 feet deep, or by reinforced concrete floors, they may be of 12-inch nominal thickness for the uppermost 70 feet, measured downward from the top of the wall, and shall be increased 4 inches in thickness for each successive 70 feet or fraction thereof.

(d) In buildings not more than three stories in height, solid masonry bearing walls of the top story may be of 8-inch nominal thickness when the total height of the wall does not exceed 35 feet, provided that such 8-inch walls do not exceed 12 feet in height and that the roof beams are horizontal.

(e) In residential buildings not more than three stories in height, solid masonry bearing walls may be of 8-inch nominal thickness when not over 35 feet in height. Such walls in one-story single-family dwellings, and 1-story private garages, may be of 6-inch nominal thickness when not over 9 feet in height, provided that when gable construction is used an additional 6 feet is permitted to the peak of the gable.

(f) Solid masonry walls above roof level, 12 feet or less in height, enclosing stairways, elevator shafts, penthouses, or bulkheads may be of 8-inch nominal thickness and may be considered as neither increasing the height nor requiring any increase in the thickness of the wall below, provided the requirements for allowable stresses are met.

Note.—For requirements for lateral support, see Section 4, Lateral Support; for hollow walls, see Section 9, Cavity Walls and Hollow Walls of Solid Units; for veneered walls, see Section 10, Veneered Walls; for faced walls, see Section 11, Faced Walls.

5–2. Thickness of Solid Masonry Nonbearing Walls.—Nonbearing walls of solid masonry may be 4 inches less in thickness than required for bearing walls, but the nominal thickness shall be not less than 8 inches except where 6-inch walls are specifically permitted.

NOTE.—For requirements for lateral support, see Section 4, Lateral Support.

5–3. Bond.—The facing and backing of solid masonry walls shall be bonded either with at least one full header course in each seven courses, or with at least one full-length header in each 1.5 square feet of wall surface. The distance between adjacent full-length headers shall not exceed 20 inches either vertically or horizontally. In solid brick walls of more than 8-inch nominal thickness, the inner joints of header courses shall be covered with another header course which shall break joints with the course below.

SECTION 6. WALLS OF STRUCTURAL CLAY TILE OR HOLLOW CONCRETE MASONRY UNITS

6–1. Thickness and Height.

(a) The thickness of walls of structural clay tile or hollow concrete masonry units shall be sufficient at all points to keep the combined stresses due to live, dead, and other loads for which the building is designed within the limits prescribed by Section 3, Allowable Stresses in Masonry.

(b) The minimum thickness of walls of structural clay tile or hollow concrete masonry units shall be not less than that required for solid masonry walls under Section 5, Solid Masonry Walls.

(c) Walls of structural clay tile or hollow concrete masonry units shall not exceed 50 feet in height above the support of such walls.

NOTE.—For requirements for lateral support, see Section 4, Lateral Support.

6–2. Bond.

(a) Hollow masonry units shall have full mortar coverage of the face shells in both the horizontal and vertical joints.

(b) Where two or more hollow units are used to make up the thickness of a wall, the stretcher courses shall be bonded at vertical intervals not exceeding 34 inches by lapping at least 3¾ inches over the unit below, or by lapping with units at least 50 percent greater in thickness than the units below at vertical intervals not exceeding 17 inches.

(c) Where walls of hollow masonry units are decreased in thickness, a course of solid masonry shall be interposed between the wall below and the thinner wall above.

SECTION 7. SOLID WALLS OF PLAIN CONCRETE

7–1. Thickness.

(a) The thickness of walls of plain concrete shall be sufficient at all points to keep the combined stresses due to live, dead, and other loads for which the building is designed within the limits prescribed by Section 3, Allowable Stresses in Masonry.

(b) The minimum thickness of walls of plain concrete may be 2 inches less than that required for solid masonry walls in Section 5,

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Solid Masonry Walls, but not less than 8 inches, except that 6-inch walls of plain concrete may be permitted where 6-inch walls are specifically permitted by Section 5–1 (e).

Note.—For requirements for lateral support, see Section 4, Lateral Suport; for hollow walls, see Section 9, Cavity Walls and Hollow Walls of Solid Units; for veneered walls, see Section 10, Veneered walls; for faced walls, see Section 11, Faced Walls.

7–2. Plain Concrete.—Except as otherwise specifically provided in these requirements, the Building Regulations for Reinforced Concrete, ACI 318–41 shall be deemed to be the generally accepted good practice in plain concrete construction.

7–3. Reinforcement.—Reinforcement symmetrically disposed in the thickness of the wall shall be placed not less than 1 inch above and 2 inches below openings and extend not less than 24 inches each side of such openings or be of equivalent length with hooks. The reinforcement both above and below shall consist of one ⅝-inch round rod for each 6 inches in wall thickness or fraction thereof.

SECTION 8. STONE WALLS

8–1. Thickness.

(a) The thickness of stone walls shall be sufficient at all points to keep the combined stresses due to live, dead, and other loads for which the building is designed within the limits prescribed by Section 3, Allowable Stresses in Masonry.

(b) The minimum thickness of walls of stone ashlar shall be not less than that required for solid masonry walls under Section 5, Solid Masonry Walls.

(c) Rubble stone walls shall be 4 inches thicker than is required for solid masonry walls of the same respective heights, but in no case less than 16 inches thick.

Note.—For requirements for lateral support, see Section 4, Lateral Support.

8–2. Bond.

(a) In ashlar masonry, bond stones uniformly distributed shall be provided to the extent of not less than 10 percent of the area.

(b) Rubble stone masonry 24 inches or less in thickness shall have bond stones with a maximum spacing of 3 feet vertically and horizontally, and if the masonry is of greater thickness than 24 inches, shall have one bond stone for each 6 square feet of wall surface on both sides.

SECTION 9. CAVITY WALLS AND HOLLOW WALLS OF SOLID UNITS

9–1. Allowable Stresses.—In cavity walls and in hollow walls of solid masonry units, the compressive stresses in psi of gross cross-sectional area shall not exceed the following:

	psi
Solid masonry units with mortar A	125
Solid masonry units with mortar B	100
Hollow masonry units with mortar A	60
Hollow masonry units with mortar B	50
Plain concrete	300

Note.—See Section 3–2 for composite walls and Section 2–16 for types of mortar permitted in cavity walls.

6–2. Height.—Except as otherwise limited by Section 9–3 (a), cavity walls and hollow walls of solid masonry units shall not exceed 35 feet in height.

9–3. Thickness.

(a) Cavity walls and hollow walls of solid masonry units shall be not less in thickness than required for solid masonry walls in Section 5, Solid Masonry Walls, provided that 10-inch cavity walls shall not exceed 25 feet in height.

(b) In cavity walls neither the facing nor backing shall be less than 3¾ inches in nominal thickness, and the cavity shall be not less than 2 inches nor more than 3 inches in width.

Note.—For requirements for lateral support, see Section 4, Lateral Support.

9–4. Bond.

(a) In hollow walls of solid masonry units, the facing and backing shall be securely tied together with headers or bonding units, as required for solid masonry walls in Section 5–3 so that the parts of the wall will exert common action under the load.

(b) Where such walls are decreased in thickness, a course of solid masonry shall be interposed between the wall below and the thinner wall above.

(c) In cavity walls the facing and backing shall be securely tied together with suitable bonding ties of adequate strength. A steel rod 3/16 inch in diameter or a metal tie of equivalent stiffness coated with a noncorroding metal or other approved protective coating shall be used for each 3 square feet of wall surface. Where hollow masonry units are laid with the cells vertical, rectangular ties shall be used; in other walls the ends of ties shall be bent to 90-degree angles to provide hooks not less than 2 inches long. Ties shall be embedded in horizontal joints of the facing and backing. Additional bonding ties shall be provided at all openings, spaced not more than 3 feet apart around the perimeter and within 12 inches of the opening. Cavity walls of plain concrete shall be reinforced as provided in Section 7, Solid Walls of Plain Concrete.

9–5. Drainage.—In cavity walls the cavity shall be kept clear of mortar droppings during construction. Approved flashing shall be installed and adequate drainage provided to keep dampness away from the backing.

SECTION 10. VENEERED WALLS

10–1. Material.

(a) Materials used for veneering shall be of the following thicknesses:

Material	Thickness
	Inches
Stone	Not less than 3.
Cellular architectural terra cotta	Not less than 3.
Architectural terra cotta slabs	Not less than 1¼.
Brick (clay, concrete or sand-lime)	Not less than 2¼.
Cast stone	Not less than 1½.
Structural clay tile	Not less than 1¾.
Flat tile	Not more than 1.
Other approved masonry	As approved by building official.

(b) In stone ashlar, each stone shall have a reasonably uniform thickness, but all stones need not necessarily be of the same thickness.

10–2. Allowable Stresses.—The maximum allowable compressive stresses on the backing of veneered walls shall not exceed those prescribed in Section 3, Allowable Stresses in Masonry, for masonry of the type which forms such backing. In no case shall the veneering be considered a part of the wall in computing the strength of bearing walls, nor shall it be considered a part of the required thickness of bearing walls.

10–3. Height.—Veneer shall not exceed 35 feet in height above foundations or other approved support.

10–4. Attachment of Veneering.

(a) The veneering shall be tied into the masonry backing either by a header for every 300 square inches of wall surface or by substantial, noncorrodible metal wall ties spaced not father apart than 16 inches vertically and 24 inches horizontally. Headers shall project at least 3¾ inches into the backing. When veneering is used, special care shall be taken to fill all joints flush with mortar around openings.

(b) Masonry veneer on frame structures shall be securely attached to the structure at intervals of not more than 16 inches vertically and 24 inches horizontally, with noncorrodible nails or ties.

SECTION 11. FACED WALLS

11–1. Material.—Materials used in the backing and facing of faced walls shall conform in all respects to the requirements prescribed for such materials in Section 2, Materials. Materials used for facing shall be not less than 2¼ inches thick, and in no case less in thickness than one-eighth the height of the unit.

11–2. Allowable Stresses.—The compressive stresses in faced walls shall not exceed those permitted for composite walls in Section 3–2. Where bonded to the backing as prescribed in Section 11–4, the full cross section of both the facing and the backing may be considered in computing the stresses.

11–3. Thickness.—Faced walls shall be not less in thickness than is required for masonry walls of either of the types forming the facing and the backing. Where bonded to the backing as provided in Section 11–4, the facing may be considered a part of the wall thickness.

Note.—For requirements for lateral support, see Section 4, Lateral Support.

11–4. Bond.

(*a*) Brick facing shall be bonded to the backing, as prescribed in Section 5–3 for solid masonry walls.

(*b*) Ashlar facing of either natural or cast stone shall have at least 20 percent of the superficial area extending not less than 3¾ inches into the backing to form bond stones, which shall be uniformly distributed throughout the wall.

(c) Every projecting stone, and, except when alternate courses are full bond courses, every stone not a bond stone shall be securely anchored to the backing with substantial noncorrodible metal anchors with a cross section of not less than 0.2 square inch. There shall be at least one anchor to each stone and not less than two anchors for each stone more than 2 feet in length and 3 square feet in superficial

area. Facing stones not over 12 square feet in area shall have at least one anchor to each 4 square feet of superficial face area.

(d) When walls of structural clay tile or hollow concrete masonry units are faced with hollow units, the facing units shall be bonded to the backing as required by Section 6, Walls of Structural Clay Tile or Hollow Concrete Masonry Units.

SECTION 12. FOUNDATION WALLS

12–1. Foundation walls shall be of sufficient strength and thickness to resist lateral pressures from adjacent earth and to support their vertical loads without exceeding the stresses specified in Section 3, Allowable Stresses in Masonry; provided, that in no case shall their thickness be less than the walls immediately above them, except as provided in Section 12–3.

12–2. Foundation walls shall be of not less than 12-inch nominal minimum thickness, except as follows:

(a) Solid masonry walls reinforced with at least one ⅜-inch round deformed bar, continuous from footing to top of foundation wall, for each 2 feet of length of the wall, may be of 8-inch nominal thickness.

(b) Solid foundation walls of solid masonry units or of coursed stone that do not extend more than 5 feet below the adjacent finished ground level, and hollow walls of masonry and walls of hollow units that do not extend more than 4 feet below the adjacent finished ground level, may be 8 inches in nominal minimum thickness. These depths may be increased to a maximum of 7 feet with the approval of the building official when he is satisfied that soil conditions warrant such increase. The total height of the foundation wall and the wall supported shall not exceed that permitted by these requirements for 8-inch walls.

(c) Foundation walls of rubble stone shall be at least 16 inches thick. Rough or random rubble without bonding or level beds shall not be used as foundations for walls exceeding 35 feet in height, nor shall coursed bonded rubble walls be used as foundations for walls exceeding 50 feet in height.

(d) Foundation walls of cast-in-place concrete shall be at least 8 inches thick; provided that when supporting one-story structures, and the area within the foundation walls is not excavated, they may be 6 inches thick if the total height of the foundation wall and the wall supported is within the allowable height of 6-inch walls.

12–3. Foundation walls of 8-inch nominal thickness and conforming to the provisions of this section may be used as foundations for single-family dwellings with walls of brick veneer on frame walls, or with nominal 10-inch cavity walls, provided that the dwelling is not more than 1½ stories in height and the total height of the wall, including the gable, is not more than 20 feet. Foundation walls of 8-inch nominal thickness supporting brick veneer or cavity walls shall be corbelled with solid units to provide a bearing the full thickness of the wall above. The total projection shall not exceed 2 inches with individual corbels projecting not more than one-third the height of the unit. The top corbel course shall be not higher than the bottom of floor joists and shall be a full header course.

12–4. Foundation walls shall extend below the level of frost action.

SECTION 13. PIERS

The unsupported height of piers shall not exceed 10 times their least dimension. When structural clay tile or hollow concrete masonry units are used for isolated piers to support beams and girders, the cellular spaces shall be filled solidly with concrete or type A mortar, and when so constructed the allowable stresses may be increased 25 percent, provided that unfilled hollow piers may be used if their unsupported height is not more than four times their least dimension.

SECTION 14. STRUCTURAL GLASS BLOCK

Glass blocks may be used in exterior or interior nonbearing walls, or where windows are permitted. All glass-block construction shall be nonload-bearing. Glass blocks shall be laid in mortar or in approved metal frames and shall be installed in accordance with generally accepted good practice.

NOTE.—In the absence of recognized standards of national technical organizations, the specifications issued by manufacturers of glass blocks shall be deemed to be the generally accepted good practice in glass-block installation.

SECTION 15. PARAPET WALLS

Parapet walls shall be at least 8 inches in nominal thickness. They shall be not higher than four times their thickness unless laterally supported; provided that when reinforced both horizontally and vertically with not less than ¼-inch rods spaced not more than 2 feet on centers, the height shall be not more than six times the thickness. All parapet walls shall have a coping of incombustible material.

SECTION 16. PARTITIONS

16–1. Bearing Partitions.—Bearing partitions shall be of sufficient thickness to support their vertical loads without exceeding the stresses specified in Section 3, Allowable Stresses in Masonry, but not less in thickness than required for walls by Section 4, Lateral Support.

16–2. Nonbearing Partitions.—Nonbearing partitions of masonry shall be built solidly against floor and ceiling construction below and above, and shall not exceed the following unsupported heights:

Thickness exclusive of plaster	Maximum unsupported height
Inches	*Feet*
2	9[a]
3	12
4	15
6	20
8	25

[a] Not over 6 feet in length.

SECTION 17. MISCELLANEOUS MASONRY REQUIREMENTS

17–1. Bonding of Wall Intersections.

(a) Masonry walls shall be securely anchored or bonded at points where they intersect and where they abut or adjoin the frame of a skeleton frame building.

(b) When two bearing walls meet or intersect and the courses are built up together, the intersections shall be bonded by laying in a true bond at least 50 percent of the units at the intersection.

(c) When the courses of meeting or intersecting bearing walls are carried up separately, the perpendicular joint shall be regularly toothed or blocked with 8-inch maximum offsets and the joints provided with metal anchors having a minimum section of ¼ inch by 1½ inches with ends bent up at least 2 inches, or with crosspins to form anchorage. Such anchors shall be at least 2 feet long and the maximum spacing shall be 4 feet.

(d) Meeting or intersecting nonbearing walls shall be bonded or anchored to each other in an approved manner.

17–2. Anchoring of Walls.

(a) Masonry walls shall be securely anchored to each tier of wood joists or wood beams bearing on them at maximum intervals of 6 feet in one- and two-family dwellings, and 4 feet in other buildings, by metal anchors having a minimum cross-section of ¼ inch by 1¼ inches, and at least 16 inches long, securely fastened to the joists or beams and provided with split and upset ends or other approved means for building into masonry. Girders shall be similarly anchored at their bearings. Anchors shall be attached in a manner to be self-releasing.

(b) Masonry walls parallel to wood joists or wood beams shall be provided with similar anchors at maximum intervals of 8 feet in one- and two-family dwellings, and 6 feet in other buildings, engaging three joints or beams. Upset and T-ends on anchors shall develop the full strength of the anchor strap.

(c) Cast-in-place concrete slabs bearing on masonry walls shall be considered as sufficient anchorage for the supporting walls.

17–3. Chases and Recesses.

(a) There shall be no chases in walls of less than 12-inch nominal thickness or within the required area of any pier, and no chase in any wall shall be deeper than one-third the wall thickness, except that in dwellings not over two stories in height vertical chases may be built in 8-inch walls under the following limitations:

In 8-inch bearing walls the chases shall not exceed 4 inches in depth, 30 inches in width, and 2 feet in height and shall not extend below the level of joist bearing, provided that where such chases occur below window sills the width may be not in excess of the width of the window opening above. In any case, not less than 4 inches of masonry shall remain between the back of chase and exterior surface of wall, and the backs and sides of all such chases in exterior walls shall be waterproofed and insulated. Masonry directly over chases wider than 12 inches shall be supported on lintels. Chases permitted in 8-inch walls shall not be cut but shall be built in as construction progresses.

(b) No horizontal chase shall exceed 4 feet in length, nor shall the horizontal projection of any diagonal chase exceed 4 feet in length. There shall be at least 7¾ inches of masonry between chases and the jambs of openings.

(c) Recesses for stairways or elevators may be left in walls, but in no case shall the walls at such points be reduced to less than 12 inches unless reinforced by additional piers, or by columns or girders of steel, reinforced masonry, or concrete, securely anchored to the walls on each side of such recesses. Recesses for alcoves and similar purposes shall

have not less than 8 inches of material at the back. Such recesses shall be not more than 8 feet in width, and shall be arched over or spanned with lintels.

(d) The aggregate area of recesses and chases in any wall shall not exceed one-quarter the whole area of the face of the wall in any story.

(e) Chases and recesses shall not be cut in hollow walls, cavity walls, or walls of hollow masonry units, but when permitted may be built in.

17–4. Lintels and Arches.

(a) The masonry above openings shall be supported by arches or lintels of metal or masonry, plain or reinforced, which shall bear on the wall at each end for not less than 4 inches. Stone or other nonreinforced masonry lintels shall not be used unless supplemented on the inside of the wall with iron or steel lintels or with suitable masonry arches or reinforced masonry lintels carrying the masonry backing.

(b) Steel or reinforced masonry lintels shall be of sufficient strength to carry the superimposed load without deflection of more than 1/360 of the clear span.

(c) Masonry arches shall have at least 1-inch rise for each foot of span and shall be designed to carry the superimposed load. Proper provision shall be made for resisting lateral thrust.

17–5. Separation of Combustible Structural Members.

(a) No wall of 8-inch nominal thickness shall be broken into, subsequent to building, for the insertion of structural members.

(b) A separation of at least 4 inches of solid masonry shall be provided between combustible members which may enter walls from opposite sides.

(c) When unprotected steel or combustible structural members frame into hollow walls of thickness not greater than 12 inches, they shall project not more than 4 inches into the wall and shall be so spaced that the distance between embedded ends is not less than 4 inches. The space above, below, and between such members shall be filled solidly with burned-clay materials, mortar, concrete, or equivalent fire-resistive material to a depth of not less than 4 inches on all sides of the members.

(d) All open cells in tiles or blocks occurring at wall ends shall be filled solidly with concrete for a depth of at least 6 inches, or closure tiles set in the opposite direction shall be used.

17–6. Beam Supports.—Beams, joists, girders, or other concentrated loads, supported by a wall or pier, shall have bearing at least 3 inches in length upon solid masonry not less than 4 inches thick or on a metal bearing plate of adequate design and dimensions to distribute safely the loads on the wall or pier.

17–7. Corbelling of Chimneys.

(a) No chimney shall be corbelled from a hollow wall, cavity wall, or a wall built of hollow units.

(b) No solid masonry wall of less than 12-inch nominal thickness shall be used to support a corbelled chimney. Corbelling shall project not more than 6 inches from the face of the wall, and individual corbels shall project not more than one-third the height of the unit.

17–8. Cornices.—The centers of gravity of stone cornices shall be inside of the outer wall face. Terra cotta or metal cornices shall be structurally supported.

SECTION 18. EXISTING WALLS

18–1. An existing masonry wall may be used in the renewal or extension of a building provided that under the new conditions it meets the requirements of this standard and is structurally sound or can be made so by reasonable repairs.

18–2. Existing masonry walls which are structurally sound but which are of insufficient thickness when increased in height shall be strengthened by an addition of the same material not less than 8 inches in thickness laid in type A mortar. The foundations and lateral support shall be equivalent to those elsewhere required for newly constructed walls under similar conditions. All linings shall be thoroughly bonded into existing masonry by toothings to assure combined action of wall and lining. Such toothings shall be distributed uniformly throughout the wall and shall aggregate in vertical cross-sectional area not less than 15 percent of the total vertical area of the lining. Stresses in the masonry under the new conditions shall not exceed the allowable stresses prescribed for composite walls in Section 3–2.

18–3. No existing wall shall be used for renewal or extension of a building, or increased in height without specific written permission from the building official.

SECTION 19. ERECTION

19–1. Masonry shall be protected against freezing for at least 48 hours after being laid. Unless adequte precautions against freezing are taken, no masonry shall be built when the temperature is below 32° F on a rising temperature or below 40° F on a falling temperature, at the point where the work is in progress. No frozen materials shall be built upon.

19–2. Brick (clay or shale) laid in other than type D mortar shall be wetted when laid unless their gain in weight resulting from partial immerson flatwise in ⅛ inch of water for 1 minute is less than ¾ ounce.

19–3. Except when carried independently by girders at each floor, no wall shall be built up more than 25 feet in height in advance of other walls of the building.

19–4. No masonry shall be supported on wooden girders or other form of wood construction.

19–5. No timber, except nailing blocks not exceeding an ordinary brick in size, shall be placed in masonry walls; but this shall not preclude the use, on exterior walls, for decorative purposes only, of timber members against the masonry or set into the masonry to no greater extent than permitted for chases.

19–6. During erection, walls shall be adequately braced.

APPENDIX

The Appendix consists of explanatory matter referring to various parts of the recommended code requirements. It is not a part of the American Standard Building Code Requirements for Masonry but is presented as background material for users of the standard. The subdivisions of the Appendix are numbered to correspond with the section numbers of the standard.

1–3. Tests.—In other sections of the standard, requirements are set forth covering the quality of materials to be used in buildings. The purpose of Section 1–3 is to give the building official authority to require tests of such materials in case there is reason to doubt their quality or their conformity to the intent of the standard. Under the provisions of this section the building official may require tests to be repeated if at any time there is reason to believe that a material no longer conforms to the requirements on which its approval was based. For the most part the specifications referred to include standard methods of testing or refer to standard methods. The building official should insist on strict adherence to these standard methods in all official tests.

Since differences in the chemical composition of the raw materials from which the units are made may cause differences in the color or structure of finished masonry units, visual inspection alone should not be considered a sufficient basis for rejection.

1–4. Second-hand materials.—Irrespective of the original grading of masonry units, compliance with code requirements of material which has been exposed to weather for a term of years cannot be assumed in the absence of test. Much salvaged brick comes from the demolition of old buildings constructed of solid brick masonry in which hard-burned bricks were used on the exterior and salmon brick as back up, and, since the color differences which guided the original brick masons in their sorting and selecting of bricks become obscured with exposure and contact with mortar, there is a definite danger that these salmon bricks may be used for exterior exposure with consequent rapid and excessive disintegration. Often a similar practice is followed with other masonry units. Before permitting their use, the building official should satisfy himself that second-hand materials are suitable for the proposed location and conditions of use.

1–5. Materials and methods of construction not covered in these requirements.—Procedures for approving new constructions having merit should be as simple as possible so that use of such constructions, when justified by available information or by readily ascertainable facts, will not be retarded unduly. If records of service performance covering a period of several years, or the results of laboratory or field tests that either are similarly time-consuming or of prohibitive cost, are required as proof of acceptability, the development and utilization of improved or less costly materials and methods will be discouraged. On the other hand, perfunctory or otherwise inadequate investigations and requirements relating to novel constructions may lead to unsafe structures.

It appears to be the concensus of experts that the desired objectives will not be attained by insisting that all new construction proposed for use be subjected to precisely the same kind of examinations and tests and be required to conform to the same limitations. In many instances, opinions of structural and materials engineers may be of more value in estimating the durability and other essential properties of an untried construction than the results of simple routine tests. Accordingly, detailed directions for investigating the adequacy of new constructions are not given, nor are all pertinent properties listed. A definite size of wall panels for structural tests and methods for conducting these tests are recommended in the belief that standardization

of these features will be of assistance in interpreting the results and will tend to minimize the need of making separate tests in each of many different localities.

Suitable methods of testing masonry walls are described in NBS Report BMS2 [1].[2]

The provisions of Section 1–4 (e) limiting the allowable compressive stress are not intended to apply to constructions built by usual methods and of materials conforming to the requirements of Section 2, even if the units, for example, are of somewhat different shape than those in common use. They are intended to apply to materials of unusual composition and to composite constructions of dissimilar materials for which there is not adequate information demonstrating suitable strength, integrity, and durability under the conditions proposed for use. For such new constructions it seems desirable to permit their use only with a factor of safety somewhat larger than is conventional for masonry until their performance in structures has been demonstrated.

2. Reference to standards [2].

Modern, well-written building codes are characterized by a liberal use of nationally recognized standards. Through their use the code writer benefits from the work of committees of national organizations having much better facilities for gathering and evaluating data than local committees can be expected to possess. Moreover, tne use of nationally recognized standards tends toward greater uniformity in codes throughout the country, an important consideration to designers, builders, and producers of material who do work in more than one locality.

Although there are several methods of utilizing nationally recognized standards, a specific method of adoption by reference has been employed in this standard.[3] The standard is referred to by title, serial, designation, year of adoption, and the name of the sponsor organization is given. Some critics of earlier drafts of the A41 standard favored a more general reference to national standards by stating that the standard "as amended from time to time" should apply. This expedient is not regarded favorably by many authorities on the subject, however, because of the possibility that the courts will refuse to uphold an ordinance utilizing such a method of reference on the ground of uncertainty as to what edition of the standard is meant, and as an improper delegation of legislative authority. While this procedure might be suitable for an ASA standard that would be used only as a reference document, the possibility that the ASA standard might be copied verbatim into a local code had also to be considered.

Constitutional provisions affecting the adoption of standards by reference vary in different States and legal opinion is somewhat divided on the question. Hence, it would be well for code writers to consult the appropriate law officer before adopting any method of utilizing nationally recognized standards, and to ascertain whether the procedure has legal sanction in order to avoid possible later attack on the method employed.

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[2] Figures in brackets indicate the literature references at the end of this Appendix.

[3] For a discussion of the use of standards, see NBS Building Materials and Structures Report BMS19, Preparation and Revision of Building Codes, by George N. Thompson, chief, Building Codes Section, National Bureau of Standards. The report is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 15 cents.

Current editions of national standards are referred to in this publication. Since these standards are revised at frequent intervals, care should be taken that the latest editions are referred to when a code is in preparation or under revision, to prevent the code becoming obsolete in this respect before it is in print. Between successive editions of the local code the building official should endeavor to put such revisions into effect by rulings, by council action. or by whatever method is permitted in his locality for amendments to the code.

2–1. Durability of masonry units.

ASTM C 62–41 T (brick, clay or shale) provides essentially a classification for durability. The classification by strength given in the note to Section 2 (e) of this specification is the one used in this code.

From the standpoint of durability the grades of ASTM Specifications for Sand-Lime Building Brick (C 73–39) are equivalent to the corresponding grades of ASTM C 62–41 T [3]. Sand-lime bricks differ from bricks made from clay and shale in that the compressive and transverse strengths of sand-lime bricks are much better correlated with the results of durability tests than are the same properties of bricks made from clay and shale. Like certain concrete units, high-strength sand-lime bricks tend to gain strength during laboratory cycles of freezing and thawing.

Few, if any, data have been obtained on the durability of concrete bricks tested as bricks. The results of numerous tests on mortars and concretes warrant the conclusion, however, that the requirement of 2,500 psi for compressive strength of the grade A brick of ASTM C 55–37 will reasonably insure durability where exposures correspond to those considered in this code. ASTM C 55–37 does not provide a minimum age for test. It may be assumed, however, that the physical requirements specified apply to material "at the time of delivery." The objection to the use of concrete bricks at early ages is based upon the observed tendency for excessive shrinkage rather than upon low strength. Steam curing under pressure is considered to be advantageous both from the standpoint of decreasing subsequent shrinkage and increasing early strength [4].

Since temperature must drop below 32° F for freezing to occur, it follows that in those sections of the United States where temperatures seldom fall below freezing, the degree of durability called for by grade SW of ASTM C 62–41 T and ASTM C 53–37 and grade A of C 55–37 is unnecessary. Those portions of the South Atlantic States excluding mountainous areas, the Gulf States, and the Pacific coastal region would not require compliance with grade SW as far as resistance to frost action is concerned.

Laboratory experiments [5] also indicate that the effect of freezing and thawing cycles in producing disintegration is related to the degree of saturation of the test specimen while being frozen. The nearer the water content of a porous body approaches complete saturation (all pores completely filled), the greater the tendency to fail when frozen. High saturations result from continuous contact with or immersion in water or intermittent wetting under conditions such that moisture does not excape from the unit. Masonry in contact with water-bearing soil, as in a retaining wall or foundation, or parapet walls poorly protected on their horizontal surface and sealed by a through flashing and an impermeable coating, such as oil paint or bitumin, on one or both of the vertical surfaces, may be highly

saturated. Numerous instances have been noted where disintegration of the inside face of a parapet followed sealing.

When water is in contact with a surface of a dry unit, the tendency is for the water to enter the unit by capillary suction. If there is enough water and the time of contact is sufficiently long, the water will strike through from face to face, giving a degree of saturation equaling or exceeding that resulting from a 24 hour submersion in water at room temperature. This wetting through from face to face describes the condition of being "permeated," referred to in ASTM C 62–41 T. In the absence of defective workmanship, masonry protected from above by flashing and with only one vertical surface exposed is unlikely to be permeated with water by ordinary weather. An additional degree of safety results from the probability that freezing weather will only occasionally follow a heavy and long continued rain without some intermediate drying. In general, units with high rates of absorption have correspondingly rapid rates of drying. The probability of permeation is obviously affected by the amount and nature of precipitation. Precipitation as snow would not introduce water into vertical surfaces. ASTM C 62–41 T takes account of this probability by permitting the use of grade NW bricks for exterior exposure where the average annual precipitation is less than 20 inches. Disregarding snow as precipitation, that portion of the United States west of a north and south line through the center of Kansas can in general be considered as having an annual precipitation of less than 20 inches.

With respect to stone, the term "durability" should be understood to include resistance to all weathering agents to which the stone is exposed, and in cases of steps, floors, etc., resistance to abrasion. Weathering agents of most concern are heat, cold, moisture, and atmospheric gases. The question of durability for a given stone can usually be settled by examining structures showing the stone under uses similar to those proposed. For such studies the stone producer or local stonesetter should be called upon for a list of structures. Untried stones under consideration for important structures should not be used before thorough testing in the laboratory.

2–14. Mortar requirements.

Water retention, one of the factors of workability of mortar is limited by the requirements of Section 2–14 (a). The measure of water retentivity is the flow of the mortar after suction for 1 minute, expressed as a percentage of initial flow. In measuring the flow, a standard mold 4 inches in diameter at the base, is placed on a flow table and filled with mortar. The flow table consists of a rigid frame with a flat, circular metal top so mounted on a vertical shaft that it can be raised and dropped through a fixed height by means of a rotated cam. The mold is then removed, after which the table is dropped 25 times in 15 seconds through a height of ½ inch. The flow is the resulting increase in diameter of the mortar mass expressed as a percentage of the original diameter (4 inches). Thus, a mortar flow of 100 percent indicates that the diameter of the mortar mass after being subjected to 25 drops of the flow table was 8 inches.

In conducting the water retention test prescribed in Section 2-14 (a), the mortar is brought to an initial flow of from 100 to 115 percent and is then subjected to a vacuum of 2 inches of mercury (section) for 1 minute, after which the flow is again determined. If the intial and

final flows of the mortar were 110 and 77 percent, respectively, the water retentivity (flow after section) would be 77/110×100, or 70 percent.

A mortar is workable if its consistency is such that it can be placed and spread with little effort but, on the other hand, is not so liquid that it deforms under its own weight or flows out of vertical joints. The property of adhering to a vertical surface or to the underside of a horizontal surface would be considered a factor in workability by the mason. Other things being equal, the water content of the mortar controls flow, which, in turn, is a measure of the consistency of the mortar.

The practical application of the water-retention test is its simulation of conditions under which masonry is laid. When mortar is spread in contact with a dry, absorptive brick, for example, the tendency is for the brick to remove water from the mortar by capillary action. In the water-retention test this process is simulated by applying suction to the sample. A mortar of poor water retentivity is objectionable for three reasons: (1) Removal of water through contact with absorptive units so stiffens the mortar that the joint cannot be controlled and leveled, (2) water retentivity is so well correlated with workability that it can be assumed that poor water retention means poor workability, apart from the use of absorptive units, and (3) mortars that stiffen rapidly when in contact with absorptive units will not make intimate contact nor bond well with these units unless brought into contact more rapidly than is customary in practice and thus will result in a weak bond and leaky joints [6]. Usually the ingredients of mortar, other than organic admixtures, that add to its plasticity also promote its water retentivity.

In Section 2–14 (b) the upper limit of not more than 3 parts of aggregate by volume to 1 part of cementitious material (sum of portland cement and lime, or masonry cement) is set to minimize: (1) harsh-working mortar resulting from over-sanding, with resultant defective workmanship, (2) excessive weathering of the mortar, and (3) lowering of strength. Since the volume changes resulting from wetting and drying of hardened mortars are greater for rich than for lean mixtures, the minimum ratio of aggregate to cementitious material is limited to 2.

2–15. Classification of mortar.

The strength of a mortar serves as a convenient approximate indication of other properties, such as durability. Although the strength of masonry is not directly proportional to the strength of mortar, an increase in mortar strength is associated with an increase in masonry strength where other factors remain unchanged. Strength of mortar has therefore been specified as one of the requirements, in addition to the two given in Section 2–14, that are intended to insure a workable, durable, and satisfactory mortar for the locations set forth in Section 2–16.

The strength classification in Section 2–15 (a) represents the minimum strengths that may be reasonably expected from cement-lime-sand mortars of the proportions indicated in Section 2–15 (b) mixed with sufficient water to give "mason's consistency" and using plastic lime putty. The use of lime as hydrate may be expected to increase materially these strengths.

Optional methods of classifying mortar are presented in Sections 2–15 (b) and 2–15 (c). The proportions given in Section 2–15 (b) are those commonly used in building construction and for which there is sufficient laboratory experience to establish the classifications. To provide for the two usual methods of job proportioning, that is, by sack measurement or by cubic-foot measure, a range has been given in the proportions, since a sack of hydrated lime may contain 1¼ cubic feet. The note following the table provides information on the weight-volume relation of mortar materials.

The composition method of classifying mortars given in Section 2–15 (b), although perhaps adequate for the majority of jobs, does not take into account the variation in mortar ingredients nor the wide range in properties of masonry cements. A given masonry cement may be a mixture of portland cement and hydrated lime; a hydraulic lime; a natural cement; lime plus a puzzolanic material, such as slag; a portland cement diluted with limestone dust; or all of these with or without various admixtures, the presence of which may greatly modify properties. Compressive strengths at 28 days have been reported [7, 8] as covering a very wide range for mortars made from commercial masonry cements. The same investigators reported a comparable range in durability as measured by resistance to freezing and thawing.

To meet the objections inherent in the composition method of classifying mortar, an alternative method is provided in Section 2–15 (c), in which the strength classification is determined by tests made in accordance with specified methods. The requirement assumes that a request will be made to classify a mortar of given proportions in one of the four classes specified in Section 2–15 (a). The decision of the building official as to the proper classification may be based upon an investigation of the claims for the given mortar, or he may accept duly authenticated reports from recognized sources. In either case it is the intent of the requirement that samples be prepared in the laboratory from materials representative of those to be used on the job, and in the given proportions. The test cubes should be cured as provided in Section 2–15 (c) and tested in accordance with the prescribed test method.

No provision has been made in this section for a check test by the building official on samples of mortar taken directly from the job. Two reasons entered into the committee's decision on this point. One was that it would be necessary to determine the classification of the mortar prior to starting the job in view of the 28-day curing period of the test. The second reason was that the check test was considered to be an administrative matter that would be covered in detail in the administration section of a complete code and was therefore not strictly within the scope of the project. Section 1–3 provides in general terms for such check testing as the building official may deem necessary and is intended to provide authority for the building official to test mortar classified under the provisions of Section 2–15 (c) if he has any doubt as to whether the mortar continues to meet the classification during the progress of the job.

2–16. Types of mortar required.

Type A mortar is characterized by rapid gain in strength, high strength, and high modulus of elasticity and, when used with units of

low rate of absorption, gives high bond strength. For these reasons type A mortar is required for foundation walls of hollow masonry units and 10-inch cavity walls, which may not have adquate lateral strength if constructed with weaker mortars. To assure that a new masonry lining of an existing wall will be effective in preventing the overloading of the latter, it is essential that the masonry of the lining does not undergo large elastic and plastic deformations, even when loaded at an early age. Type A mortars are required for such linings, because they quickly attain a relatively high modulus of elasticity and do not undergo excessive plastic deformations under the allowed stresses.

Type B mortar, having a compressive strength of not less than 600 psi at 28 days, is considered to have satisfactory durability and strength for use with solid units below finished grade, for load-bearing and exterior walls, and for general use except in those locations and for the kinds of construction for which type A mortar is specifically required.

Type C mortar has a low resistance to frost action when saturated and hence is not recommended for use in locations in which the mortar will be in contact with the soil. Its use is permitted in exterior and interior walls of solid masonry, in interior nonload-bearing walls or partitions of hollow units, and in other locations for which type A or type B mortars are not specifically required.

Mortars of type D ordinarily are slow setting and develop a moderate strength and resistance to weathering only after long aging under favorable conditions. They may soften if kept wet. Because of their very low strength at early ages and uncertain resistance to weathering, they are not recommended for use in parapet walls, rubble stone walls, of where in contact with the soil. To compensate for the low resistance to lateral forces of walls built with type D mortars, lower limits on height and on spacing of lateral supports are recommended than for walls built with stronger mortars.

3. Allowable stresses in masonry.

Recommended allowable compressive tresses are given for several varieties of masonry, the values depending upon the type of mortar and for some varieties upon the strength of the masonry units. Whenever justified by the available information on the strength of masonry, the allowable stresses are the same for masonry of two or more types of units, thereby avoiding unwarranted duplication. The grouping chosen appears to be the simplest compatible with design stresses that will afford reasonable assurance of safety without being the cause of uneconomical construction.

Although the compressive strength of masonry depends upon several factors [9, 10] in addition to the strengths of the units and mortar, the posible effects of the other factors on strength of masonry are minimized by limitations in the code and in the specifications for the materials. For example, variations in strength resulting fr[illegible] differences in bonding, dangerously unfavorable curing, or extre[illegible] values of height and thickness of members are limited by requireme[illegible] pertaining to these factors. Moreover, specifications for maso[illegible] units include requirements on size, shape, and uniformity, as w[illegible] as on other significant physical properties. To an important deg[illegible] therefore, much of the otherwise possible uncertainty about stren[illegible]

is reduced for masonry conforming to the requirements of this standard.

Quality of workmanship also has an important effect on the compressive strength of masonry. Highest strengths are obtained with masonry having completely filled mortar joints, and with the bearing shells and webs of hollow units alined in all courses [11, 12]. This kind of workmanship is difficult to obtain with some units, costs more than "commercial" workmanship, and rarely is found throughout the masonry portions of buildings. The committee agreed that allowable stresses should be based on commercial workmanship, which has been described as being representative of what is generally obtained in commercial construction, where close supervision is not to be expected and the most cogent consideration is economy.

The allowable stresses given in the several subdivisions of Section 3 are for the most part approximately the same as those recommended by the former Building Code Committee of the Department of Commerce [13, 14]. In the absence of test data the allowable stresses for type C mortar have been interpolated.

The specifications for hollow masonry units (Sections 2–4, 2–5, and 2–10) include requirements not only on minimum compressive strength but also on the features of design (shape) of the units that have an important effect upon the compressive strength of masonry walls. These requirements (which apply to end- and to side-construction structural clay tile, to glazed building units, and to hollow concrete units having face shells of different thicknesses) are such that the minimum compressive strengths are approximately the same for walls built with hollow units of each type covered by these specifications. For this reason, requirements on the design of the units are not included in the A41 standard and the recommended allowable stresses are the same for masonry of the various types of hollow units. The recommended stresses differ but little from those allowed by most of the codes which do not include more restrictive limitations on the units.

3–1 (b). Higher stresses.

The maximum stresses recommended in Section 3 were selected after a consideration of the unregulated or uncontrollable elements affecting the strengths of materials. However, as conditions of use and standards of quality are better defined and controlled, the factor of safety may be reduced. Hence, in order to take advantage of improvements in materials and methods of construction, authority has been given to the building official to permit higher stresses in design, upon a satisfactory showing that materials of a higher grade or workmanship superior to that found in generally accepted good practice will be employed under approved inspection.

It has been suggested that this provision might subject the building official to pressure from groups intent on gaining an advantage for a given material. The committee recognized this possibility, but it was of the opinion that some discretion must be given to the enforcing official if building codes are to be kept flexible to meet changing conditions. The former Building Code Committee of the Department of Commerce in its report Recommended Minimum Requirements for Masonry Wall Construction [13] permitted an increase of 50 percent in the allowable compressive stresses for brick masonry

under specified conditions of workmanship and where the effects of all loads and forces were considered. It appears, however, that the increased stresses have been written into some local codes without these qualifying provisions. To avoid this, the committee has refrained from recommending any specific increase in stresses and has made the matter discretionary with the building official when satisfactory evidence is produced that higher stresses are justified.

In passing upon such evidence, the building official should examine carefully the conditions under which the tests which support the claims for increased stresses were made. Both the size of the test specimen [15, 16] and the type of wo kmanship employed have an important bearing on the results obtained. Tests of miniature specimens, such as two units and a mortar joint, would be of comparatively little utility in predicting the strength of walls. Test assemblies should be truly representative of the workmanship and materials to be employed in the construction for which the higher stresses are requested.

The allowable stresses in Sections 3–3 and 3–4 are based upon results of tests of masonry laid with workmanship approximating that generally obtained in commercial construction. For brickwork, this type of workmanship is characterized by deep furrowing of the horizontal joints. For hollow masonry units, horizontal bedding is limited to the face shells. Workmanship characterized by full, level bed joints and filled longitudinal and end vertical joints has been shown [11, 17] to increase the compressive strength of brick masonry from 25 to 100 percent compared with the strength of the masonry built with furrowed horizontal joints. Significant increase in strength for tile and block results from increase in bearing of the bed joints [18].

3–2. Composite walls.—Limiting the allowable compressive stress in a composite wall to that allowed for one of its vertical elements seems to be a reasonable restriction, although the results of some tests [18] under short-time and concentric loading indicate an average strength somewhat higher than the strength of the weaker element. In service the portions of a wall composed of dissimilar materials may undergo unequal movements with change in temperature and moisture content and thereby cause lateral distortions and a varying distribution of stresses under constant load. However, long experience with faced walls and with structures composed of different types of masonry materials indicates that such movements are not large enough to endanger the stability of walls built in accordance with these recommendations. Another reason for this requirement is the fact that the resistance of a wall to lateral loads, causing tensile stresses in the weak element of a composite wall, depends largely on the tensile strength of that element.

4. Lateral support.—Section 4 means in brief that if vertical supports, such as columns, piers, or cross walls, are provided not more than the specified number of times the wall thickness apart, there need be no limits on the distance between floors, or that when floors are spaced not over the specified number of times the wall thickness apart, piers or other vertical members which afford lateral support are not required. It is assumed that walls will be anchored to floors, as required by Section 17–2.

5–1. Thickness of solid masonry bearing walls.

It is common in some parts of the country to designate the thickness of brick walls as 9, 13, and 17 inches, but a more general method is to

use even figures, such as 8, 12, and 16. The latter method is believed to be more nearly in accord with the actual measurements and has been used in the requirements. The figures are, however, qualified by the term "nominal," in recognition of the fact that there are unavoidable variations in mortar joints and in size of bricks. ASA Committee A62 on the Cordination of Dimensions of Building Materials and Equipment has proposed two standards: (1) The General Basis for Dimensional Coordination, A62.1, and (2) the Basis for the Coordination of Masonry, A62.2. The latter standard contains the provision that actual sizes of masonry units shall be based upon established nominal sizes which are equal to the actual dimensions plus the thickness of a mortar joint. Application standards establishing the modular sizes of masonry units are now being prepared, and when these modular sizes are used in masonry construction, the actual thickness of walls will be equal to their nominal thickness (2, 4, 6, 8, 10, 12, and 16 inches) less the thickness of a mortar joint which, as provided in the definition of nominal, cannot exceed ½ inch.

No limit has been placed on the height of solid masonry walls, since economic rather than structural considerations will control this. In unusual cases where bearing walls exceeding this height are used, special care should be employed both in design and workmanship.

In a survey reported by the National Bureau of Standards in 1923, 41 percent of the local building codes examined permitted construction of two-story dwellings with 8-inch exterior brick walls. In 1937, another survey made by the same agency showed 84 percent of codes examined permitting such construction. With such a substantial increase in use, it may be said that the 8-inch wall for dwellings is now firmly established. A further step has been taken in the requirements in permitting 6-inch walls for single-family dwellings and private garages of limited height. It is recognized that such a wall thickness will require a special unit, and it is understood that these are in process of manufacture. The committee believes that, within the limits specified, such units may be used with safety.

Some building codes establish limits of span for floors supported by bearing walls, requiring a greater wall thickness where such limits are exceeded. This practice is believed to date back to the era when working stresses for masonry were not limited directly, but by controlling the live loads likely to come upon the walls. When masonry stresses are kept within the limits prescribed in Section 3, and lateral supports conform to the requirements of Section 4, the span of floor beams (within the limits imposed by other considerations) appears to be unrelated to the necessary thickness of masonry walls.

In some places which are subject to high winds, trouble has been experienced with thin masonry walls, but no evidence has been received indicating that the pressures resulting from maximum wind velocities in most parts of this country have caused failures of enclosing masonry walls having lateral supports in accordance with the provisions of Section 4. Neither an 8-inch nor a 12-inch wall of considerable height has the inherent stability to resist high wind pressures but, if the building enclosed possesses sufficient mass and stiffness to resist collapse as a whole, it appears that walls having thicknesses within the limits prescribed in Section 5–1 have sufficient resistance to withstand all but the most severe winds.

5–2. Thickness of solid masonry nonbearing walls.—It is especially important that exterior nonbearing walls be well anchored to floors

or other members providing lateral support, since they do not gain added stability from superimposed loads, as in the case of bearing walls. Details of anchorage are discussed under that heading in Sections 17–1 and 17–2.

5–3. **Bond.**—The requirements for bond in this section are somewhat more liberal than in many existing codes. A common requirement has been that in brick walls at least every sixth course shall be a header course or there shall be at least one full-length header in every 72 squares inches of wall surface. The data [16, 19] are somewhat contradictory as to the effect on compressive strength of masonry of increasing or decreasing the number of header courses. Some tests [20, 21] indicate that highest strengths are obtained under central loading with masonry having no headers. Headers are needed to cause common action of the vertical elements of walls under lateral loads and they assist to distribute eccentric loads, but both the results of laboratory tests and service records of structures indicate that the number required by many existing codes could be reduced substantially without having a practical effect on the strength or stability of masonry.

6–1. **Thickness and height of walls of structural clay tile or hollow concrete masonry units.**—Although some codes limit the height and use of 8-inch walls more than is done in the present standard, experience, particularly within the last few years, has shown that the limitations established in the standard are satisfactory. Considerations that entered into the decision concerning these walls included the fact that requirements for lateral support provide adequate stiffening and that, in the case of occupancies having heavy floor loads, such loads increase the vertical components of the applied pressure and add to the stability against lateral forces.

7–1. **Thickness of solid walls of plain concrete.**—In view of the fact that the thickness of walls of plain concrete may be controlled by the spacing of forms and that a somewhat greater stress in compression is permitted than for masonry of solid units, the minimum thickness of walls of plain concrete has been set at 2 inches less than for walls of solid units. This reduction does not extend to walls of 8- and 6-inch thickness, however, since in the absence of information justifying the use of thinner walls the committee is of the belief that these dimensions should not be further reduced.

8–1. **Thickness of stone walls.**—Required minimum thicknesses for walls of stone follow conventional practice as recorded in many local codes. Experience has demonstrated that the thicknesses given are adequate for walls conforming to the other requirements.

9. **Cavity walls and hollow walls of solid units.**—Code practice varies in the method of treatment of hollow walls. Some codes classify walls either as solid or hollow, the latter term denoting walls of hollow units as well as hollow walls of solid units and cavity walls. In other codes the term "hollow wall" applies only to the type that provides air spaces between the units, but no differentiation is made between the various types of hollow walls. The practice therefore is somewhat confusing, requiring frequent reference to the definitions to determine the type of wall to which the provisions apply.

In this standard, walls of hollow units are covered in Section 6 and the two types of hollow walls in Section 9. A distinction is made between the two general types of hollow walls merely to avoid confusion, since the requirements are substantially the same for either

type. The rolok-bak and all-rolok walls are examples of the hollow wall of solid units in which the bond consists of masonry headers as distinguished from the cavity wall in which the two tiers are completely separated except for the metal ties.

The hollow wall of solid units formerly used to some extent in this country has largely been replaced in recent years by the cavity wall. The cavity wall has been used successfully in England for many years and is reported at present to be the most commonly used type for housing. Limited in this country to houses and low buildings until recently, the cavity wall has now begun to find use in panel walls of multistory buildings.

With cavity walls the loads are usually carried by the inner tier. The outer tier is customarily 4 inches thick and increases in thickness are made in the inner tier. A nominal 10-inch cavity wall consists of two nominal 4-inch tiers and a 2-inch air space, or cavity. A nominal 14-inch cavity wall consists of a nominal 4-inch outer tier, a 2-inch cavity, and a nominal 8-inch inner tier. Tests at the National Bureau of Standards [22] have shown that the 10-inch brick cavity wall loaded on both the facing and backing will support about the same load as an 8-inch solid brick wall. When loaded on the backing only, the 10-inch brick cavity wall supported about 80 percent of the maximum load carried by an 8-inch solid brick wall. Under transverse loading the 10-inch cavity wall of either solid or hollow units has about one-half the strength of the 8-inch solid wall [17, 22, 23, 24].

In view of the uncertainty as to the manner of loading cavity walls in actual practice, and as a more convenient method of computing the strength of the wall, the allowable stresses have been based on the gross area of the wall. The allowable stresses have been reduced from those permitted for solid walls to compensate for the increased gross area provided by the cavity. The required net thickness of cavity walls (exclusive of cavity) has been made the same as that for solid masonry walls but, to assist in obtaining adequate wind resistance, the use of type A mortar has been made mandatory in Section 2–16 for the nominal 10-inch cavity wall.

The heights permitted by Section 9–2 are believed sufficient to provide for the buildings which would ordinarily be built with this type of construction.

Because of the difficulty of covering all possible conditions, only general requirements are set up in Section 9–5 for flashing. Since one of the purposes of the cavity is to provide a barrier against the penetration of moisture, it is essential to provide flashing wherever the cavity has been bridged for any purpose, such as heads and jambs of openings, joist bearing points, etc. Where dampness prevails in the soil against the foundation, a dampproof course should be provided above the grade and below the underside of the first-floor construction to prevent water from rising into the wall by capillarity [25].

Proper drainage should be provided at the base of the cavity to dispose of any water which might penetrate the cavity. This is sometimes accomplished by providing weep holes in the vertical joints of the bottom course of masonry of the outer tier. The requirement that the cavity shall be kept clear of mortar droppings is for the purpose of insuring that the weep holes are not obstructed. The mortar droppings can be collected on wooden slats which are placed on the wall ties, as these are laid and removed before setting the next course of ties.

9–4. Bond.

Ties in cavity walls serve as struts or tension members, causing the two tiers to deflect about equally when a wall is subjected to bending moments. However, the flexural rigidities of the usual types of ties are too small to transmit shearing forces large enough to cause the two tiers to exert common action. Investigations have shown that the resistance of steel wall ties to compressive and tensile loads depends in part on the size and shape of the tie and the strength of the mortar embedment [26]. These studies indicate that 3/16-inch-diameter rods in mortar of type A or B have sufficient strength and stiffness to prevent excessive deformations.

Although there is some evidence that a useful life of 20 years or more may be obtained with steel ties having no protection against corrosion, experience with such unprotected ties in this country has been too limited to justify their general use. For most exposures and types of structures, sufficient protection is afforded by coatings of coal-tar paint or of zinc or other corrosion-resistant metal.

The performance of cavity walls when subjected to lateral forces or to vertical loads on one of the tiers indicates that one tie for each three square feet of wall area is all that is needed to assure substantially equal deflections of the two tiers of a cavity wall [22, 23, 24]. As the lateral forces may be more concentrated around openings, and as resistance to these forces is less in these regions than elsewhere, additional ties are required near the perimeters of openings.

10–4. Attachment of veneering.

The requirements for attachment of veneering have been intentionally stated in general terms in order to afford latitude in design. Where more detailed requirements are desired, the following is deemed to be good practice in satisfying the requirements of this section:

(a) For attachment of brick veneering on masonry, one substantial noncorroding metal wall tie shall be used for each 300 square inches of wall surface.

(b) For attachment of architectural terra cotta and other molded units on masonry, one noncorroding metal anchor at least equal to 5/16-inch round, or 1/8 inch by 3/4 inch flat in sectional area, to each piece, and two or more such anchors to all pieces over 18 inches in length or more than 300 square inches in superficial area, except where such architectural terra-cotta facing is bonded and completely filled with the brick backing.

(c) For attachment of stone veneering on masonry, one noncorroding anchor at least 3/16 inch by 1 inch flat, or its equivalent in cross-sectional area, to each piece over 1/2 square foot in face area, and at least two anchors to all pieces over 24 inches in length or more than 400 square inches in superficial area.

12. Foundation walls.

Some difficulty was experienced by the committee in arriving at a satisfactory definition of this type of wall, and examination of a number of representative codes discloses considerable variation in the meaning of the term. As commonly understood, however, a foundation wall is one that serves as a retaining wall in addition to furnishing support for the walls above, hence connoting underground. It follows from this understanding of the term that the finished ground surface marks in general the upper limit of the foundation wall. However, since the wall between floors must be considered

as a unit, the term "foundation wall" and the provisions applying to it are intended to apply to the entire height of wall in the story when any part of the wall is below ground level.

For buildings on fairly level ground, the present definition is adequate. The main floor will usually be at or slightly above or below the finished ground surface and the foundation wall will extend up to that floor. Likewise, in the case of buildings built on sloping ground, the front and rear foundation walls will extend up to the floor nearest the finished ground surface. The side foundation walls in such a case would extend up at least to the finished ground surface, although practical considerations will usually require that they be of uniform thickness up to the floor nearest to the finished ground surface in order to avoid an offset in the wall thickness in the exposed face of the wall. From a structural standpoint, it is also desirable that a uniform thickness be maintained up to the floor level, and such a requirement is given in Section 4–5.

12–2. Minimum thickness of foundation walls.

The committee is aware that in somewhat rare instances, foundation walls conforming to the requirements of Section 12 may have insufficient strength or stability to withstand the lateral pressures imposed, and that, on the other hand, the requirements may be more restrictive than needed for some structures and soil conditions. Aside from the transverse strength of the wall [18, 27, 28], the factors which have the greatest effect upon the lateral stability of a given wall are: (1) earth pressure, (2) strength and rigidity of the lateral supports (usually the footing and the first floor above), and (3) the vertical load on the wall. The lateral pressure may be zero, or it may approach the hydrostatic pressure of a liquid having the density of mud. The probable maximum pressure for the foundation walls of a structure can be estimated closely only by those familiar with the conditions at the site.

Foundation walls of the materials and dimensions ordinarily used are not stable against earth pressures unless restrained against horizontal movement at the top and bottom or along closely spaced vertical elements. Usually the spacing of cross walls is too great for them to serve as the only lateral supports. Therefore, it is essential that the floors be so anchored and connected as to restrain the top of the wall, and that the bottom be restrained at the footing.

Vertical compressive loads on foundation walls resulting from the weight of the building and its contents tend to prevent the development of or to reduce the magnitude of the vertical tensile stresses caused by lateral earth pressures. The resistance to lateral pressures of a given foundation wall is therefore increased by an increase in the weight of the superstructure. For example, if the maximum tensile stress in the foundation wall for a one-story light wood-frame house were 20 psi, this stress probably would be reduced to 5 or 10 psi if the superstructure were changed to a typical three-story house with 8-inch brick walls. The use of thinner foundation walls for light than for heavy structures, as permitted by some codes, is not justified by a consideration of lateral stability.

The transverse strength of walls of reinforced solid masonry not only is greater than for similar nonreinforced walls but it is also more uniform and reliable. The information available [24] indicates that walls reinforced with ⅜-inch round bars 2 feet apart, or the equivalent in smaller bars or wires, has adequate resistance under all conditions

commonly encountered. The heights of the back fill against other types of 8-inch walls of unit masonry are limited to values related to their expected resistance to lateral pressures.

13. Piers.—Tests have shown that when walls of hollow units are built entirely with cells vertical and with webs carefully superposed, their compressive strength is materially increased in comparison to walls of hollow units laid with the cells horizontal. Since it is believed that filling the cells with concrete will help to insure the webs being superposed, the increase permitted in Section 13 would seem to be justified. The provision that unfilled piers of hollow units may be used when their height does not exceed four times their least dimension is intended to apply to minor structures, such as summer cottages and accessory buildings.

15. Parapet walls.

The provisions of this section are intended to regulate only the structural features of parapet walls. Other standards in the series of American Standard Building Code Requirements will specify when parapet walls are required.

The limits on the ratios of height to thickness of parapet walls specified in this section are believed to be safe for ordinary conditions. In localities subject to high winds or to earthquakes, somewhat more rigid restrictions may be advisable. The committee recommends the use of reinforcement as a means of preventing cracks or opened joints or the movement of the wall.

Particular attention should be paid to the flashing, dampproofing, and workmanship of parapet walls to prevent disintegration. Through flashing should be provided under the coping, unless the coping is of an impervious material laid with watertight joints, and also at the base of the wall. All joints should be well filled, and exterior joints should be tooled with a round jointer. Coating, or sealing, of the back of the wall with vapor impermeable materials is not recommended, as this practice prevents rapid drying of the masonry.

16–2. Nonbearing partitions.—It has been pointed out by critics of earlier drafts of this standard that the provision that partitions shall be built solidly against floor and ceiling construction is interpreted by some building inspectors as requiring that steel wedges shall be used to wedge the partition tightly against the ceiling. Such is not the committee's intent in the present section. The customary practice of using small pieces of the partition material to wedge the top of the partition to the ceiling and then slushing the joint full of mortar from both sides of the partition is believed to provide adequate anchorage of the partition to the ceiling.

17–3. Chases and recesses.—The exception to the usual requirement that there shall be no chases in 8-inch walls is made to provide for ducts of warm-air heating systems in dwellings, and for the recessing of radiators under windows. Since the grilles must be located in exterior walls in many cases, and since the 8-inch wall is the common practice in dwellings, it was deemed necessary to provide space in the wall for the elbow of the duct where it makes the turn from the grille to the branch line located between the floor joists. The committee was of the opinion that chases of the dimensions permitted in this section would not weaken the wall to any serious extent and

would permit of some economy and convenience in the installation of the heating system. As no load of any importance is carried by the masonry under the window sills, it was felt that recesses for radiators could safely be permitted under the conditions set forth in this section.

19–1. Winter construction.—The procedures used in cold weather concreting apply with little modification to construction of masonry at temperatures below freezing. The recommendations for thawing of aggregates apply to masonry units if exposed so that they contain water, and freeze. The effects of low temperature on the setting and the strength gain of mortars are similar to the effects on concrete. For more detailed information on this subject the reader is referred to "Concreting in Cold Weather," Bulletin No. ST21 of the Portland Cement Association, and to "Brick Engineering", published by the Structural Clay Products Institute.

19–2. Wetting of bricks (clay or shale).

Evidence is available that the strength of bond in tension and in shear between mortar and masonry unit is related to the rate of suction of the unit. [29] There is general agreement among investigators that rates of suction exceeding 1 ounce per brick in the first minute are associated with low bond strengths and with poor results on water-permeability tests, and these difficulties are accentuated with increasing rates of suction.

Evidence is also available that suitably wetting clay or shale bricks of medium to high rates of suction increases the strength of bond between brick and mortar and permits a more effective filling of joints as shown by reduction in permeability to water.

A rough but effective test for determining what bricks give improved bond by wetting consists in sprinkling a few drops of water on the flat of the brick and noting the time required for these drops of water to be absorbed completely. If this time exceeds 1 minute, wetting is not needed. A refinement of this method consists in drawing a circle 1 inch in diameter on the flat of the brick with a wax pencil (using a 25-cent piece as a guide provides a circle of almost the exact dimension). One milliliter of water (20 drops) is applied to the surface thus limited and the time for complete absorption is noted [30]. If this time exceeds 1½ minutes, the bricks need not be wetted; if less than 1½ minutes, wetting is recommended.

Wetting of vitrified and semivitrified bricks or excessive wetting of other bricks is undesirable because of resultant floating of the bricks and "bleeding" of the mortar. A satisfactory procedure consists in playing a stream of water on a pile of bricks until water is observed to run from each individual brick visible in the pile. Unless the bricks are exposed to conditions favoring the rapid evaporation of moisture, one wetting per day is sufficient.

19–3. Erection.—The vulnerability of excessively high masonry walls to lateral forces before they are braced by floor or roof construction is not always taken into account in construction operations. Although the committee recognizes the danger of excessively high unbraced construction, it also appreciates that it is sometimes necessary to build one wall to a full-story height before erecting other parts of the structure. A limit of 25 feet has therefore been set, coupled with a provision that walls shall be adequately braced during construction.

Construction to resist earthquakes

Through ASA Sectional Committee A58 on Building Code Requirements for Minimum Design Loads in Buildings, the attention of the committee has been called to the desirability of certain specific provisions regarding masonry in areas where earthquakes are probable. Items suggested for consideration include allowable types of mortar, use of bond beams and columns, bonding of exterior veneer, use of hollow-unit masonry, and details of interior partitions. These matters are being given consideration and will be the subject of recommendations in a later edition of the committee's report. It is expected that these recommendations, taken in conjunction with the recommendations of Sectional Committee A58 as to design for resistance of horizontal forces, will provide a suitable basis for safe construction in areas where earthquakes are a factor.

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